Energy Management Initiative – Wave 4

HELPING YOUR WWTP SAVE ENERGY AND IMPROVE PROCESS PERFORMANCE

Larry W. Moore, Ph.D., P.E.
University of Memphis

August 4, 2016

Presentation Outline

- Dr. Moore and our program
- What we need from you
- Brief description of the activated sludge process
- Determining oxygen requirements
- Determining performance of aeration equipment
- Case study results

Dr. Moore and Our Program

- 43 years of wastewater treatment experience
- Provided engineering and operating guidance to over 250 municipal and industrial WWTPs throughout the U.S. (mostly in Tennessee)
- Dr. Moore has his own biokinetic model that he uses to model the activated sludge process.
- In this program, our team will help your WWTP save energy and improve process performance and effluent quality.
- We will do the energy assessment at your WWTP at no cost to your city!!!
- **Typical energy savings = 10% to 25%**

What do we need from you???

WE NEED YOUR WWTP OPERATORS TO BE WILLING TO WORK WITH US!!!

Objectives of Biological Treatment

- Oxidize dissolved and particulate biodegradable constituents into acceptable end products
- Capture suspended and nonsettleable colloidal solids into a biological floc or biofilm
- Transform or remove nutrients such as N and P
- Remove specific trace organic compounds

Primary reference: Metcalf & Eddy 4th Edition

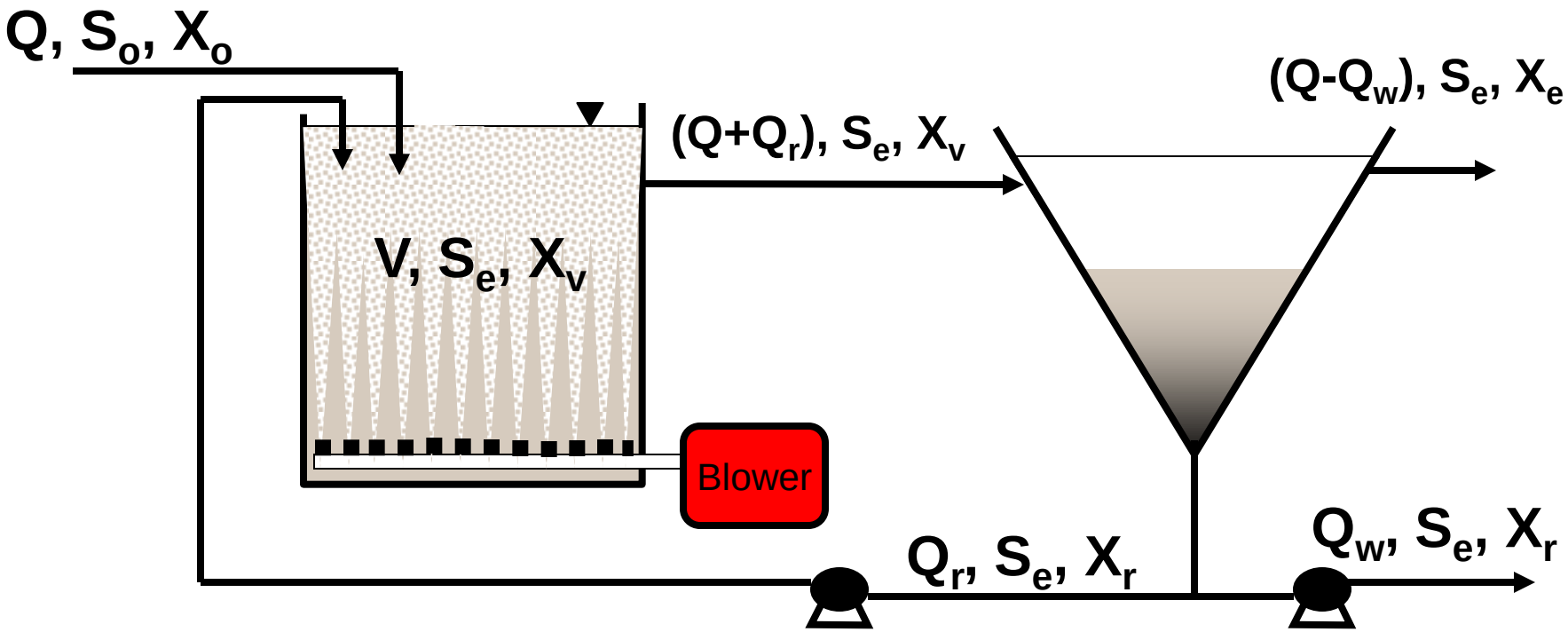
Comments about Activated Sludge

- Developed around 1913 in Massachusetts and in Manchester, England (1914)
- So named because it involved the production of an active mass of microbes capable of stabilizing a wastewater under aerobic conditions
- In aeration tank, contact time is provided for mixing and aerating influent wastewater with microbial suspension (mixed liquor)

Comments about Activated Sludge

- Mechanical equipment is used to provide mixing and oxygen transfer
- Mixed liquor flows to secondary clarifier where biomass is separated from the treated wastewater and is thickened
- Settled biomass is returned to aeration tank to continue biodegradation of influent organic material

Activated Sludge Process Schematic



Biological Reactor with Aerated Mixed Liquor (diffused aeration)

Activated Sludge Oxygen Requirements

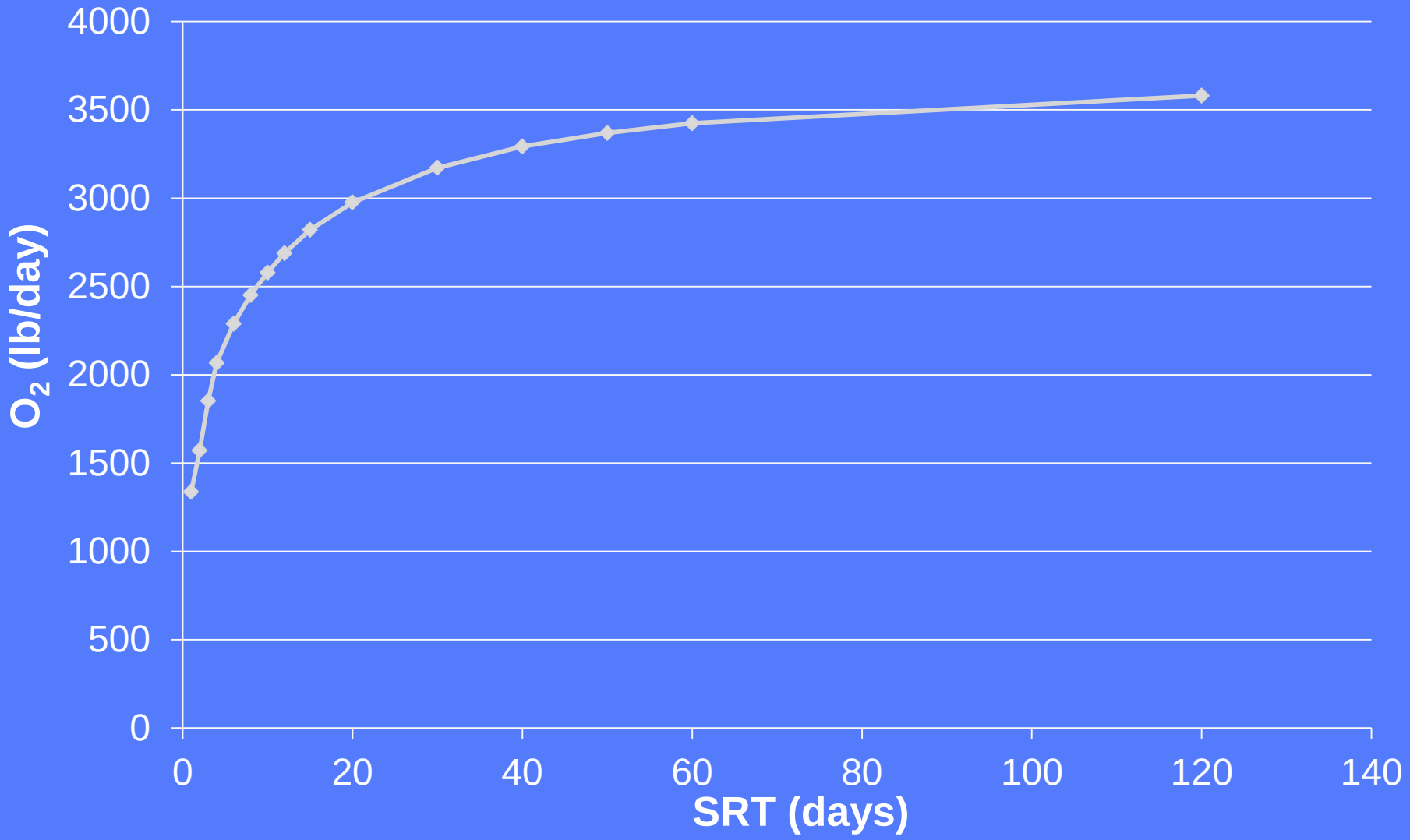
Determine the oxygen requirements (CBOD and NBOD)

$$O_2(\text{lb/day}) = 8.34Q\left[\frac{S_o - S_e}{0.67}\right] - 1.42(VSW)$$

$$+ 4.33(N_{ox})(Q)(8.34)$$

Aeration equipment typically consumes 50% to 60% of the total energy used by your WWTP!!!

Oxygen Required (Carb+Nit) vs SRT – 1.0 mgd Extended Aeration Act. Sludge



Goal: Match O_2 Supplied with O_2 Needs

- Dr. Moore uses his model to determine oxygen requirements.
- Dr. Moore uses his knowledge of aeration equipment to determine the oxygen supplied.
- In the activated sludge reactor(s), we want to supply the oxygen that is needed. **WE DO NOT WANT TO SUPPLY EXCESS OXYGEN BECAUSE THAT WASTES ENERGY!!!**
- As appropriate, we want to turn aeration equipment off to save energy and to promote nitrogen removal.

Performance of Various Types of Aeration Equipment

Approximate Field O_2 Transfer Rates

- Pump type aerators
  - 1.4 to 2.1 lb O_2/(HP-hr)
- Aspirating aerators
  - 1.2 to 1.5 lb O_2/(HP-hr)
- Horizontal rotor aerators
  - 1.5 to 2.1 lb O_2/(HP-hr)

α = 0.84, β = 0.92, ρ = 1, DO = 2 mg/L, Elevation < 500 ft

Approximate Field O_2 Transfer Rates

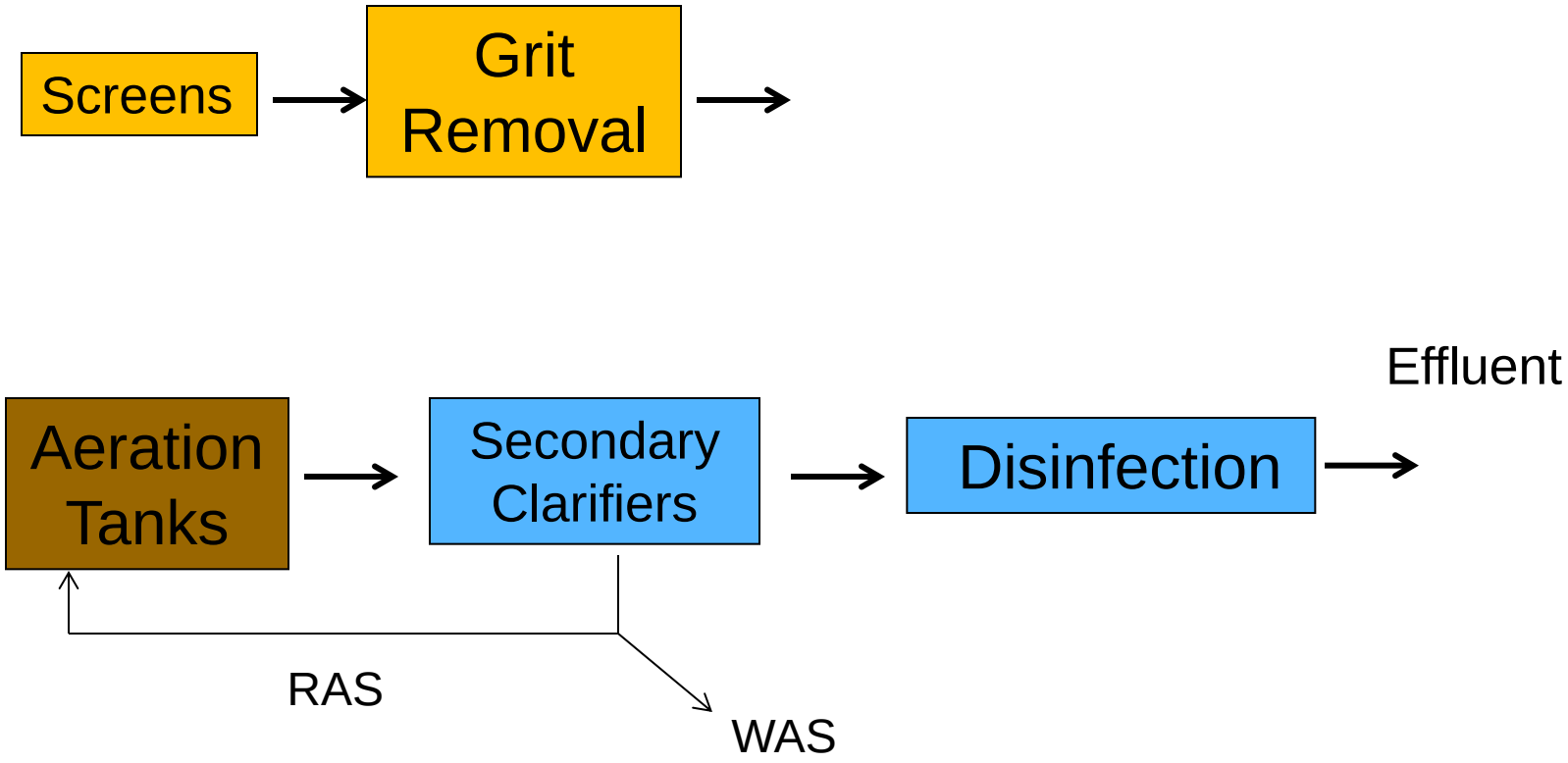
- Nonporous diffusers
  - 1.0 to 1.5 lb O_2/(HP-hr)
- Porous diffusers
  - 1.7 to 2.4 lb O_2/(HP-hr)

α = 0.84, β = 0.92, ρ = 1, DO = 2 mg/L

Elevation < 500 ft, Compressor efficiency = 75%

Tank depth = 15 ft, Diffusers located 1.5 ft above tank bottom

Case Study: Wetumpka WWTP



Wetumpka, Alabama WWTP

Case Study: Wetumpka WWTP

Total average daily flow rate	1.5 mgd (half to each aer tank)
Aeration volume in service	6.8 mil gal (3.4 mil gal each)
Influent BOD_5 concentration	150 mg/L
Influent BOD_5 mass loading	1880 lb/day (total)
Biomass inventory (MLVSS)	88,000 lb (in aeration tanks)

Case Study: Wetumpka WWTP

Biomass inventory (MLSS)	153,000 lb (in aeration tanks)
F/M ratio	0.021 lb BOD_5/(lb MLVSS-day)
Solids Retention Time	115 days
MLSS	2700 mg/L
MLVSS	1550 mg/L

Case Study: Wetumpka WWTP

TSS Sludge Production	1300 lb/day (intentional wastage)
TSS in activated sludge effluent	60 lb/day (unintentional wastage)
Oxygen Requirements for Act Sldg (actual)	4600 lb/day
Total Oxygen Requirements (actual)	**4600 lb/day**

Case Study: Wetumpka WWTP

Total Oxygen Supplied*	**7700 lb/day**
Mixing intensity in aeration tanks with 460 hp	68 hp/mil gal
RAS flow rate	1.5 mgd (total)
WAS flow rate	0.029 mgd
RAS TSS concentration	5500 mg/L

*All aerators running 6 hours/day

Recommendations

1. **Use only one aeration basin.**
2. **Operate two 75-hp aerators and two 40-hp mixers 18 hours/day.**
3. **No aeration for 6 hours/day**

Wetumpka WWTP Results

Energy savings	≈ **38,000 kWh per month**
Energy cost savings	= **$5,830 per month**
CO_2 reduction	> **390 tons/year**
Eff Total N reduction	= **12 tons/year (62%)**

***All with no capital outlay**